APPROPRIATE TYPE OF DIGITAL CAMERA FOR CRANIOFACIAL DATA ACQUISITION SYSTEM

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ABSTRACT

At present, digital camera can be purchased at reasonable price and could provide excellent output for the user. Today, a digital camera of high resolution is available and there are different types of digital camera. The user should select apropriate digital camera to suite their needs. In close range photogrammetry, digital camera has been widely employed for various applications in diversified field and could delivered the required needs or output. One of the application is the used of digital camera in medical photogrammetry. Digital camera has been reported used to acquire the information or data of human face. The data on the human face is known as craniofacial. It was proved that the compact digital camera is capable of providing the data. The Single Lens Reflex (SLR) digital camera could also be used for the acquisition of data from human face. In this study, an initial test on the performance of compact and SLR digital camera is carried out. Both types of digital cameras were calibrated using a common test field. From this study, it was found that the results of the SLR digital are superior than the results of compact digital camera. This study shows that the SLR digital camera has the potential to be used as a sensor for the craniofacial data acquisition system.

Keywords: Digital camera, craniofacial, close range photogrammetry

1.0 Introduction

Close range photogrammetry has evolves rapidly from analogue to analytical and today it has embraces the digital technology and known as Digital Close Range Photogrammetry (DCRP). In DCRP, there are many instruments that can be used for data acquisition and data processing. However, the most important instrument is the digital sensor. The digital sensor could be a digital camera, CCD (*Charge Couple Device*) camera, video camera or others. Today there are various digital sensor types and models that are available in the market including digital camera. The digital camera could be in various make form, cost, resolution and format. Also the price of digital camera is becoming cheaper same as the price of computer. Therefore the user of digital camera could select appropriate digital camera for their needs. However, in DCRP the digital camera must be calibrated so that it could produce good results. In DCRP, many studies have been carried out using digital camera for various applications including study on the assessment of precision and accuracy aspect.

Close range photogrammetry has been reported used in diversified applications and different fields such as in industrial applications, medical, archaeology, architecture, map revision and others. Close range photogrammetry offers many advantages such as non-contact measurement, portable, precise, delivers the output in short period, cost saving and others. In close range photogrammetry, point measurement is the prime focus where the 3D coordinates of discrete points on the object or surround the object of interest will be determined (Fraser, 1996; 1997; Ahmad and Chandler, 1999). In many applications of close range photogrammetry, retro-reflective targets were often used and the targeted points together with the object are photographed using different type of sensor whether it is based on film or digital and the sensor could be of metric or non-metric types. Today, with the advent in computer technology and software, many studies have been reported using digital camera. There are many makes and models of digital camera that could be used in DCRP. However, it was found that many digital cameras of Kodak series were reported used in close range photogrammetric applications such as the Kodak DCS200, Kodak DCS420 and Kodak DCS460. These digital cameras are of the “Single Lens Reflex” (SLR) types. However, digital cameras in the form of compact such as the Kodak DC40, DC50, DC120, DC210, DC220, DC280 and DC290 also have been reported used in close range photogrammetric applications (Miyatsuka, 1996; Litchi and Chapman, 1997; Ahmad and Chandler, 1999; Anuar and Siti Hamisah; 2001; Anuar *et al*., 2002a; 2002b).

In close range photogrammetry, the position of the targeted points could be measured automatically using program/software developed in-house or using commercial software that are available in the market. Subsequently, the data are processed using a bundle adjustment program to determine 3D coordinates and to acquire camera calibration parameters. There are several bundle adjustment program/software that could be used such as General Adjustment Program (GAP) developed at City University, London, AUSTRALIS developed at University of Melbourne, Australia, PHOXY developed by Ingenieursbureau Geodelta bv, Delft and others. In this study, AUSTRALIS software was used to calibrate the digital camera. After calibrating the digital camera, the results of calibration which consist of camera calibration parameters were then used as data input into the digital photogrammetric sofware for data processing of the mannequin digital images.

2.0 Application of close range photogrammetry in medical

Close range photogrammetric techniques have been used in medical to record shape and size in studies relating to a wide range of areas of the human body such as torsos, heads, faces, limbs breasts, feet, skin, eyes and teeth (Newton and Mitchell, 1996). According to Newton and Mitchell (1996), close range photogrammetry has a distinct value as medical measurement tool since it uses photography which offers a quick, convenient and safe means of recording a condition at a particular point of time. In other word, close range photogrammetry offers non-contact measurement method where the patient will not get hurt or infected. Further, photography does not distort the surface being measured. Close range photogrammetry can be contrasted with other external measurement techniques such as those involving electrogoniometers and accelerometers attached to the body for movement analysis which are not only uncomfortable but can interfere with the free movement of the patient. Medical photogrammetric measurement for the diagnosis and treatment of human conditions and for biomedical research creates a class of close range photogrammetry with its own distinctive challenges and constraints. Some of the challenges and constraints are as follows:

- Medical measurement deals primarily with living human patients. Consequently, it is necessary to be concerned about their convenience, comfort, privacy and dignity. More importantly, human move continuously, even if imperceptibly over short periods of time and so quick, hence, fine synchronized imaging can be crucial.

- The measurement also involves interaction with the medical practitioner. This may require careful communication about the constraints and requirements of the measurement and the form of output. Indeed, one of the major challenges of medical photogrammetry is to provide information (e.g measurement and other information) which is appropriate, usable and medically meaningful.

- The cost of photogrammetric measurement usually needs to be kept low because the measurements are not normally crucial to saving life.

In this study, close range photogrammetry (i.e medical photogrammetry) was used to acquire data of human face (craniofacial). Human face is an important part of human anatomy. Human face is a complex surface with different depth and texture (Figure 1). For medical purpose such as face reconstruction, human face needs to be modeled and measured accurately. In Malaysia, most surgeons are still relying on laborious traditional contact method (eg. calipers) for measuring anthropometric landmarks on human face.

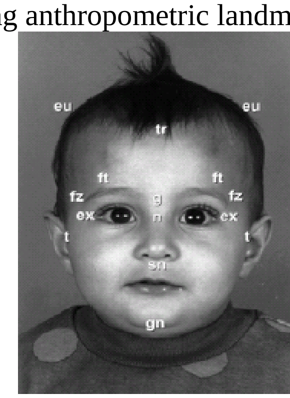


Figure 1: Human face and anthropometric landmarks

3.0 Methodology

3.1 Data acquisition

At present there are several craniofacial data capturing system (for capturing soft tissue) that are available around the world, especially at research institutes and at few hospitals. After looking at the literature and making visit to several research institutes and hospitals, we have designed a system as shown in Figure 2. The developed craniofacial data capturing system comprise of digital camera (set in stereo) as shown at position C1, C2 and C3 while two laser scanners Minolta Vivid 910 (eye saved) were positioned at position L1 and L2 for acquiring high resolution 3D models of craniofacial soft tissue (Zulkepli *et al*., 2004). After designing the system, the system was tested by acquiring data of a mannequin and compared the measurement with the caliper before acquiring real data. In the process of acquiring the data, first the digital camera was used to acquire the craniofacial images and then secondly, the laser scanner was used to acquire the data.

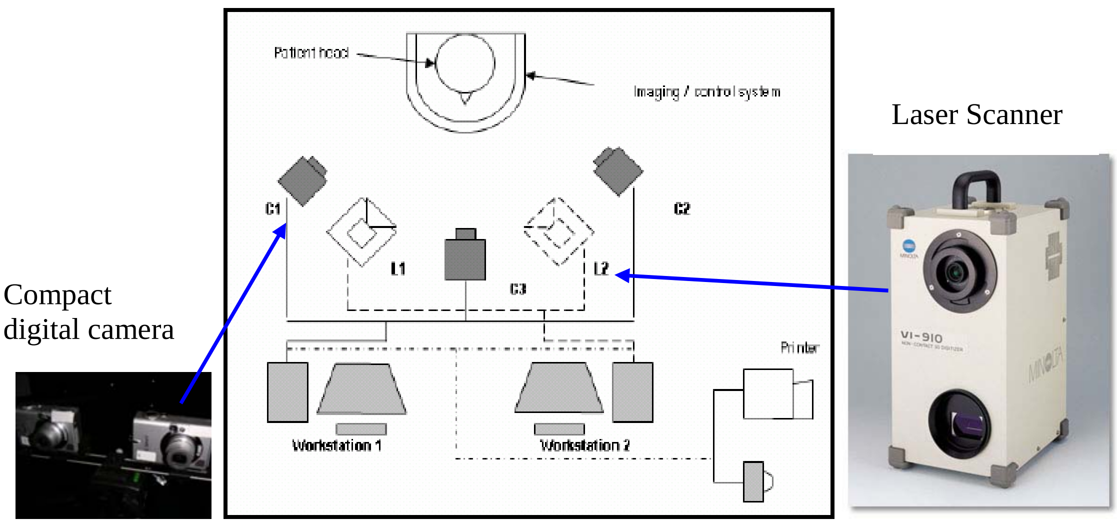
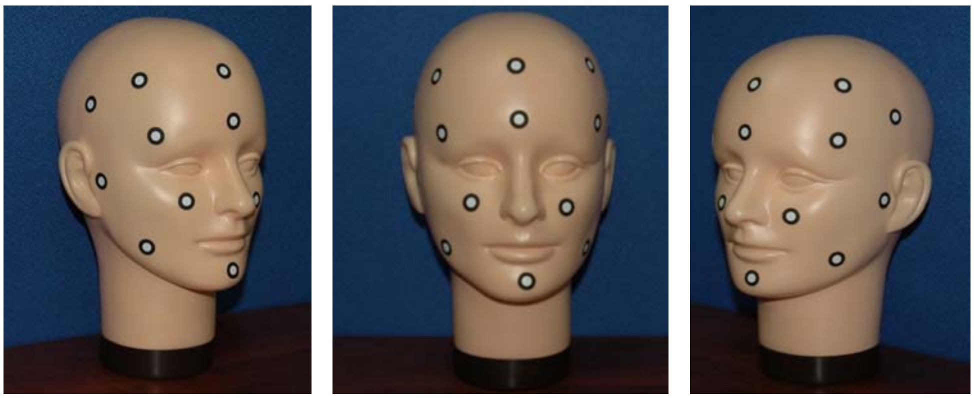


Figure 2: Craniofacial data capturing system for soft tissue

In this study, apart from using the craniofacial data capturing system as shown in Figure 2, another method was employed in the craniofacial study. In this method, Nikon D70 Single Lens Reflex (SLR) digital camera was used to acquire the images of a mannequin using convergent configuration. The purpose of using this method is to investigate whether SLR digital camera could provide better results compared to compact digital camera. Another purpose is to investigate whether convergent configuration could provide better results too since in close range photogrammetry many studies have shown that convergent configuration could deliver better and accurate results. The SLR digital camera was calibrated using a calibration plate a distance of 0.7 meter. After calibration is done the digital images of the mannequin were acquired. Figure 3 shows the SLR digital camera that was used to acquire the digital images of a mannequin. Figure 4 shows the images of a mannequin that were acquired using the SLR digital camera at three different locations in convergent configuration. Note that retro-reflective targets were used on the mannequin. The distance from the SLR digital camera to the mannequin is approximately 0.7 meter. The same mannequin was then scanned using the Minolta Vivid 910 laser scanner as shown in Figure 2.

Figure 3: Nikon D70 SLR digital camera



Right side	Front side	Left side

Figure 4: Images of mannequin acquired using Nikon D70 SLR digital camera

3.2 Data processing

After all the images of mannequin were acquired using the SLR digital camera, it were downloaded into the computer.. In brief, a few processes were carried out using a digital photogrammetric software known as Topcon PI3000 before any measurement can be observed. A 3D model of the mannequin (i.e face) was successfully produced using the digital photogrammetric software. The distances between the anthropometric landmarks were measured manually using this software. The distances between the anthropometric landmarks were measured three times (3x) and the mean is computed. The results of the anthropometric measurement are shown in the following section.

For the data acquired using the laser scanner, the data are processed using Polygon Editing Tool (PET) which comes along with the scanner. In addition, for better measurement (i.e linear and curved measurement following the profile of the human face, angle and discrete points) Rapidform software from Korea was used. This software also allows 3D model of the mannequin to be constructed. After the formation of 3D model of the mannequin using the laser scanner data, once again the distances between the anthropometric landmarks were also measured three times (3x) using Rapidform software and the mean is computed. Then the results of the anthropometric landmarks of Topcon PI3000 software were compared with the results from the laser scanner.

4.0 Results

Table 1 shows an example of the coordinates of the anthropometric landmarks of a mannequin. Topcon PI3000 was used to read the coordinates of the anthropometric landmarks as accurate as possible (for data acquired using the SLR digital camera). Each point was read three times. Then the distances between the anthropometric landmarks were computed. At the same time the distances between the anthropometric landmarks were also measured using Rapidform software (i.e laser scan data). From these two datasets, the differences were computed. The greatest distance difference was found between **tr-gn**. The difference aroused due to problem of identifying exact position of both points. Distance difference also aroused between **gn-sn**. If this point can be located correctly then there is possible that the distance difference will be less.

Table 1: Example of coordinates of the anthropometric landmarks of a mannequin using Rapidform software (i.e laser scan data)

	X (mm)	Y(mm)	Z(mm)
1. tr	271.724158	280.642779	104.068799
2. g	276.137762	217.744109	147.334662
3. n	277.528947	199.671191	146.838377
4. prn	282.078765	170.413588	175.805233
5. sn	279.883801	156.843894	168.563519
6. ls	281.662476	140.300988	168.201433
7. lsL	274.334747	141.994159	167.670950
8. lsR	288.790897	141.425079	165.702922
9. sbaL	263.631261	151.536255	154.550764
10. sbalR	291.859702	153.066489	156.518792
11. sl	282.853514	104.319044	165.046913
12. pg	282.169143	79.912378	162.422876
13. gn	282.046357	74.669876	159.544751
14. exL	223.152793	191.270540	138.284506
15. exR	330.905991	193.911182	128.190964
16. enL	257.442100	192.047899	133.079121
17. enR	295.501373	192.333860	133.803292
18. fzL	210.409472	203.336159	120.044036
19. fzR	338.994738	202.487234	118.233607
20. ftL	215.940786	212.503960	125.475321
21. ftR	334.369269	214.855987	122.216550
22. chL	251.362975	124.090339	158.787205
23. chR	308.426149	124.352687	152.269663
24. osR	313.646653	210.819189	130.934430
25. osL	239.352740	207.493213	131.590439
26. orR	316.386044	178.891606	128.310393
27. orL	241.040044	179.257878	134.870486
28. acR	303.157498	159.544107	153.355920
29. acL	254.288413	159.360444	156.614691

5.0 Conclusion

From this study, it was found that the developed system as shown in Figure 2 was capable of achieving an accuracy of ±0.5mm at standard deviation for any measured distance between two anthropometric landmarks especially using signalized target on the mannequin. For the laser scanner Minolta Vivid 910, an accuracy of ±0.1mm could be achieved. The results of the laser are more superior than the results obtained using the Topcon PI 3000 digital photogrammetric software. Even though the digital images of the mannequin were acquired using SLR digital camera and employed convergent configuration, the results are less accurate compared to the laser scanner data.

In this study, the anthropometric measurements can be used for the development of craniofacial database which are useful to craniofacial surgeons and can be used for other applications. For accurate measurement, where ever possible laser scanner could be used. However, for less accurate measurement the Topcon PI 3000 digital photogrammetric software could be used. Even though this software is not appropriate for this application, it might be useful for other applications in close range photogrammetry.

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